Online RADHARD SYMPOSIUM

Book of Abstracts

May 18th, 2021

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Chairman‘s Invitation

On behalf of the organizing team of the RADHARD Symposium 2021, it is my great pleasure to invite you to the 6th edition of the RADHARD Symposium, which is a speciation edition on Laser Testing. The RADHARD 2021 will be held online. This will ensure the necessary security for all participants during the global Covid-19 pandemic.

The mission of the RADHARD Symposium is to provide you, in addition to the RADECS Conference, with a forum for the exchange of practical experience in the field of radiation hardness assurance, which is important for both industrial applications as well as research and science. Our vision is that the RADHARD Symposium will provide a place with plenty of room for communication, initiate new joint projects and invite you to the upcoming RADECS 2021 in Vienna, Austria.

Please register now - at www.radecs2021.org

The focus of the RADHARD Symposium 2021 is on

- Principles of Laser Testing for Radiation Hardness Assurance
- Practical Aspects and Potential of Laser Testing
- Overview on State-of-the-Art Laser Testing Technology

The RADHARD Symposium is aimed at space system integrators, manufacturers of electrical and electronic equipment, industry, research and science as well as students interested in radiation and its effects on components and systems. International experts present new results and give a comprehensive overview of the current situation. We encourage students to present their early research work on radiation hardening effects and discuss with radiation hardening experts from research and industry.

Keynote speeches in this special RADHARD edition will focus on “Fundamentals of Laser Testing for Single-Event Effects” by University Montpellier and on “Laser Testing - Airbus Needs and Desirable Test Option for the Future” by Airbus. The practical aspect of laser testing will be summarized in the Session on “Laser Testing Systems” by three lectures on “Laser SEE testing with SEREEL2” by Radtest Ltd., on “PULSCAN Solution for SEE Laser Testing” by PULSCAN, and on “SEE Testing Using a MOPAW Fiber Laser with 1030 nm Emission” by Allied Scientific Pro.

We are pleased and very proud that three Invited Talks on lessons learned, current knowledge and future aspects will deepen the topic with lectures on „Experiences with Pulsed-Laser Testing for SEEs“ from the Naval Research Laboratory, on „Pulse Laser Single Event Effects: Facility Overview and Integrated Circuit Characterization Results“, from MDA, and on „SEE Laser Testing at ESA - What‘s New“ by the European Space Agency, ESA.

The RADHARD Symposium 2021 is organized by Seibersdorf Laboratories and supported by the Austrian Research Promotion Agency (FFG), the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology, AUSTROSPACE and in cooperation with Graz University of Technology, the University of Applied Sciences Wiener Neustadt and the RADECS Association.

This year‘s RADHARD Symposium is carried out in connection with the „Exploration of Single Event Effect Radiation Testing of COTS Components with Laser and Heavy Ions“ (SEELAS) project. We gratefully acknowledge the support of the project SEELAS, which is carried out within the framework of the Austrian Space Applications Program, ASAP.

The RADHARD Symposium will air on May 18, 2021 as a live on-line event and will be available as video on demand on the RADHARD website for registered participants for one month.

The event will be organized for you with many innovative ideas, with new presentation possibilities, very integrative and as a joint event with lots of fun and heart.

We wish you all an interesting RADHARD Symposium 2021!

Peter Beck

On behalf of the organizing team of the RADHARD Symposium 2021

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Rainer Gotsbacher, ecoplus, Austria

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Peter Beck, Head of Radiation Protection Dosimetry, Seibersdorf Laboratories, Austria

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Vincent Pouget, CNRS, France

Keynote - Laser Testing – Airbus Needs and Desirable Test Option for the Future
Sébastien Morand, Airbus Defence and Space, France

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Moderated by Christoph Tscherne

17:00 **Closing**

Keynote
Fundamentals of Laser Testing

Vincent Pouget[1]
[1] Institute of Electronics and Systems, CNRS, University of Montpellier, France

Abstract

The laser method for Single-Event Effects testing is based on the photoelectric interaction of a short and focused laser pulse with the semiconductor material of a device to mimic the transient and localized track of electron-hole pairs that is produced by primary or secondary ionizing particles from radiation environments. This talk introduces the fundamentals of the laser testing technique and review important experimental parameters and practical considerations, providing the required knowledge to understand the capabilities and limitations of the technique and to prepare a laser testing campaign. Typical use cases are illustrated and the question of correlation is briefly discussed.

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Keynote
Laser Testing – Airbus Needs and Desirable Test Option for the Future

Sébastien Morand[1]
[1] Airbus Defence and Space, France

Abstract

One of the most stringent selection criteria for space electronics stems from the sensitivity of a given electronic part against Single Event Effects (SEE) induced by the space environment. The identification and characterization of those effects are mandatory in order to ensure space systems proper functionality.

The standard approach to characterize Single Event Effects is to use Terrestrial Particle Accelerator that can provide beam with similar type of particles as the space environment. By testing a device under heavy ion or proton beam, the sensitivity of an electronic part can be drawn. The use of different ion linear energy transfer (LET) and different proton energy allow to quantify the sensitivity against a given environment and application case.

The number of facility that allows such type of testing is highly limited over the world. Moreover, a continuous need of testing legacy technology and the fast-growing demand of Commercial Off-The-Shelf (COTS) parts shall further limit the availability of such accelerators.

Already in the late 80's, it has been identified that pulsed laser beams could be used as an alternative means to characterize the sensitivity of electronics to radiation. The use of specific photon energy testing generates localized charged tracks induced by photon absorption from a laser pulse into a semiconductor material. Bearing in mind some physical limits, most single event effects can be reproduced in a repeatable manner.

Taking those aspects into consideration, Airbus has been one of the pioneering European industrial to develop and use an in-house SEE Laser test facility as a complementary tool to standard terrestrial beams. The use of laser testing from an industrial perspective is then shared in order to illustrate different use-case of interest and how it shall complete the existing landscape of SEE characterization means. The presentation concludes on some perspective in regards of new needs and evolution for laser testing methodologies.

Session:
Laser Testing Systems

Laser SEE Testing with SEREEL2

Richard Sharp[1]
[1] Radtest Ltd, 168 Maxwell Avenue, Harwell, OX11 0QT, United Kingdom

Abstract

For at least two decades, interest has grown in SEE testing methodologies that are alternatives to particle beams from large accelerators. Perhaps the most widespread of these is the use of pulsed lasers to deposit similar amounts of charge in a comparable timeframe and in the same place as a cosmic ray. What were once complex, research laboratory-based systems have become smaller, cheaper and easier to use as tools for routine testing. There are distinct advantages and disadvantages of using pulsed lasers for SEE testing, which will be outlined today, but their benefits in terms of flexibility and time make them a very attractive option in certain circumstances.

SEREEL2 is a second-generation laser SEE test system, based upon the latest and most reliable components. Only very stable, reliable, industrial laser sources are used. These can run for months without any need for tuning. Combined with a similar quality optical parametric analyser (OPA), this extends the capability of the system from silicon alone to the entire family of WBG materials. Modern movement stages are precise, repeatable and reliable, enabling semi-automated screening of large numbers of samples.

The presentation will highlight these benefits of SEREEL2, illustrated by examples of where the quality and reliability of the instrument pushes radiation testing into areas simply not feasible with accelerator sources.

Acknowledgments

I would like to acknowledge the work on the original SEREEL done by Andrew Chugg, Rod Jones and others at MBDA UK Ltd.

PULSCAN Solution for SEE Laser Testing

Sebastien Jonathas[1]
[1] PULSCAN, France

Abstract

This talk presents the elements and capabilities of the PULSYS-RAD equipment, Pulscan's industrial turn-key system for pulsed laser SEE testing, which makes the pulsed laser technique accessible to non-laser-experts, with field-proven capabilities on many different IC technologies [1-6].

The main elements include the laser-injected infrared microscope and the PULSBOX Pico and 2P smart laser sources respectively for Single-Photon Absorption (SPA) and Two-Photon Absorption (TPA) testing. Some advanced features of the PULSWORKS software, which provides a complete user interface to control the laser experiment as well as for data acquisition and visualization, are presented.

Laser SEE testing with SEREEL2 Different use cases are described to illustrate the wide range of applications covered by the system for parts screening, system debug, sensitivity analysis or rad-hard design.

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SEE Testing Using a MOPAW Fiber Laser with 1030 nm Emission

Rez Mani (PhD)[1], Yuhao Qiu[1], Akshat Verma[1], Mohamed Abouseif (PhD)[1] and Steeve Lavoie[1]
[1] Allied Scientific Pro, Canada

Abstract

Laser SEE testing is an alternative method of testing electronic components and devices that are space bound. Although for accurate measurement of cross section, threshold LET and error rates, particle accelerator testing is preferred, the wait time to get into one of these facilities is quite long and cost per hour is quite high as well.

The laser method can be used as a complementary method to identify error modes, disqualify faulty COTS parts and do rapid testing of electronic parts prior to a visit to a particle accelerator SEE testing facility. Allied Scientific Pro (Gatineau, Canada) has set up a Single Photon Absorption (SPA) test facility which is open to the SEE community in North America.

The facility uses a Master Oscillator with Programmable Amplitude Waveform (MOPAW)[1] fiber laser with emission at 1030 nm to do the SEE testing. SWIR and visible cameras, high quality illuminator in both visible and Near IR, high precision translation stage along 3 axes, automated scanning, LabView software control, attenuation polarizers, etc. are some of the features of the testing station. As the first step to validate the performance of the SEE testing station, a few known devices whose SEE behavior were available in literature[2] were tested.

These included a SRAM and an Op-AMP for which SEU, SEL and SET were detected and hence the performance of the SEE testing station was validated. The facility is looking forward to testing more complex devices such as FPGAs and Power MOSFETS in near future.

References

1 - Synthetic aperture ladar based on a MOPAW laser, S. Turbide et.al., Proceeding Volume 10005, Earth Resources and Environmental Remote Sensing, SPIE Remote Sensing, 2016, Edinburgh, United Kingdom.

2 - Pulsed-Laser Testing for Single-Event Effects Investigations, S.Buchner et.al., IEEE Transactions On Nuclear Science, VOL 60, NO. 3, June 2013.

Acknowledgments

We would like to thank INO (Quebec city, QC, Canada) engineers for providing us with the MOPAW laser and their useful guidance for laser control and selecting the correct laser parameters throughout the course of testing.

Invited Talks

Experiences with Pulsed-Laser Testing for SEEs

S. Buchner[1], J. Hales[2], A. Ildefonso[1], A. Khachatrian[1], D. McMorrow[1]
[1] Naval Research Laboratory, Washington, DC, USA
[2] KeyW Corp, Hanover, MD, USA

Abstract

With access to heavy-ion accelerators limited by the tremendous demand associated with the need for single-event effects (SEEs) test facilities, increased consideration is being given to alternate facilities, such as pulsed-lasers. Pulsed-lasers are a viable option for doing SEE testing because, even though photons are fundamentally different from particles, when interacting with matter, such as a semiconductor, they both liberate electrons and holes from the constituent atoms comprising the semiconductor. The liberated electrons and holes modify local electrical potentials that can cause SEEs. This is the basis for using pulsed lasers for electrical transient testing in semiconductors, a suggestion first made and demonstrated by Habing in 1965 [1], a mere five years after the invention of the laser and seven years after the invention of the integrated circuit. It took another 22 years before interest in the pulsed laser for SEE testing was rekindled [2], [3]. The field is now sufficiently mature that several competing pulsed-laser test systems, offering turnkey operation, are commercially available.

Great strides have been made in the development of the technique from its rather crude beginnings. Instead of using cumbersome pulsed lasers for producing photons with wavelengths appropriate for single-photon absorption (SPA), with the light incident from the top side of an integrated circuit, and sensitive areas delineated using crude scanning techniques, current test systems make use of compact lasers that are capable of emitting a wide variety of wavelengths suitable for both SPA and two-photon absorption (TPA), allowing for light incident from the back side of the integrated circuit as well as the front side, and having sophisticated software for stepping motors that can scan areas with step sizes of 0.1 micron and record any type of SEE at every location.

In this talk, I will briefly discuss the differences between charge tracks produced by ions and by pulsed laser light. I will then present examples illustrating the development of the pulsed laser for SEE testing, covering a wide range of technologies and the associated single-event effects. The presentation will conclude with a description of the latest developments that promise even better fidelity between SEEs produced by heavy ions and by pulsed-laser light.

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[2] S. Buchner et al., “Laser Simulation of Single Event Upsets,” IEEE Trans. Nucl. Sci. Vol. 34, No 6. Pp. 1227-1233, December 1987.

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Pulse Laser Single Event Effects: Facility Overview and Integrated Circuit Characterization Results

Dave Hiemstra[1], Li Chen[2]
[1] MDA, Brampton, Canada
[2] University of Saskatchewan, Saskatoon, Canada

Abstract

Pulsed lasers have been an effective tool in simulating single event effects in integrated circuits (IC). It can be used to estimate the SEU sensitivity of the ICs and is especially useful in diagnosing the location of single event latchup. Two-photon lasers have gained more attention during recently years since it has longer wavelength to penetrate the substrate of the ICs from the back of the ICs and better control on the focus regions.

The conventional stage-scan lasers have drawbacks due to the mechanical movement of the stage. The advanced laser-scan techniques can move the laser beams instead of the stage, which makes the scanning process much faster and more accurate. On top of that, the precise temperature control of the device-under-test (DUT) and fine step scanning are other important properties for laser setup.

The laser facility at the University of Saskatchewan is been upgrading to accommodate those issues to achieve more accurate and faster laser testing. The laser source includes both 1064nm and 1250nm for testing, and it also can achieve precise temperature control on the DUT and anti-vibration mechanism. The laser has been used for a number of test campaigns including both analog and digital ICs.

The digital circuits include: custom-designed flip-flop chains, FPGAs, and memories. The analog/mixed signal circuits include: DC-DC converter controllers, Hall effects sensors, and op amps have been tested with this facility.

SEE Laser Testing at ESA - What's new

A. Pesce[1], T. Borel[1], C. Boatella Polo[1], C. Poivey[1], A. Costantino[1], M. Muschitiello[1]
[1] ESA/ESTEC, The Netherlands
Radiation Hardness Assurance and Component Analysis Section

Abstract

The *SEE Laser testing at ESA - What's new* presentation will address the strategy in place at ESA to support the Radiation Hardness Assurance in the context of new ESA Mission Classification schemes and new approaches on the use of COTS devices and advanced technologies. Several initiatives have been supported over the years to guarantee the access to a network of irradiation facilities, guaranteeing the adequacy and availability of ion beams at various energies with a reliable dosimetry. These efforts are in continuous evolution, targeting the evolving needs required by new mission concepts and new technologies.

In line with the ESA Technology Strategy goals of improvement of spacecraft development time by 30% by 2023, one order of magnitude improvement of cost efficiency with every generation, and 30% faster development and adoption of innovative technology, ESA has launched a large initiative on COTs COTS devices, from the definition of new requirements on the selection and use of COTs COTS in different mission classes to the Open Space Innovation Platform COTS call for ideas.

As part of this strategy new investments in Lab equipment and new R&D studies have been put in place at ESA. Part of this plan included the acquisition of a SEE Laser test system, new equipment for devices opening, support to facilities to increase the availability high energy beams and enlarging the network of European supported irradiation facilities.

Although laser testing has been used to support SEE investigations, it has never been used as part of a traditional RHA program. Due to inherent challenges (e.g. correlation between laser energy and particle LET mainly), traditional SEE testing using heavy-ions and protons have always been preferred, being far more representative of the type of particle interactions and effects which can occur in orbit. However, laser testing also offers some benefits, in particular related to COTS components not designed for space environments and meant to be used to reduce the overall cost of the missions. A new study has been initiated by ESA to look at SEE Laser testing as a tool to test highly integrated and complex COTS (e.g. SoC) to highlight the sensitive areas and the various SEE modes (e.g. SEFI), reduce the number of heavy ions beam hours needed for radiation test campaigns, and be assessed as a new effective tool to screen COTs COTS devices by analyzing the SEE sensitivity changes of parts from the same lot when lot traceability is unknown.

A lot to do and to learn on the topic of SEE laser testing as part of the Radiation Hardness Assurance at ESA. Cooperation amongst actors and comparison of results are needed to define a common approach to best exploit the SEE laser testing techniques. It is thanks to events and conferences like the RADHARD Symposium that new ideas can take off.

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